

US Serial No. 10/560,804
Jawad HAIDAR

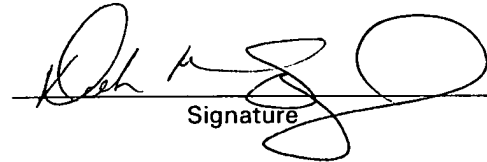
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Debra M. Szumowski
Name


Signature

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

APPLICANT:	Jawad Haidar) Group Art Unit: 1793
)
SERIAL NO:	10/560,804) Examiner: Zhu, Weiping
)
FILED:	December 15, 2005) Docket: CU-4560
TITLE:	A METHOD AND APPARATUS FOR THE PRODUCTION OF METAL COMPOUNDS	

Mail Stop: Appeal Brief - Patents
THE COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

APPEAL BRIEF UNDER 37 CFR § 41.37

Sir:

This is responsive to the Notice of Appeal dated April 1, 2010, the time for responding thereto being extended two months in accordance with the petition for extension of time submitted concurrently herewith. The following is Appellant's Appeal Brief, submitted under the provisions of 37 CFR § 41.37. This Commissioner is hereby authorized to charge any fees which may be required to Deposit Account No. 12-0400, including the fee for filing the Appeal Brief of \$540 required under the provisions of 37 CFR § 41.20.

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I. REAL PARTY IN INTEREST

The real party in interest in the present appeal is the assignee,
Commonwealth Scientific and Industrial Research Organisation.

US Serial No. 10/560,804
Jawad HAIDAR

II. RELATED APPEALS AND INTERFERENCES

None.

III. STATUS OF THE CLAIMS

Claims 1-26, 31, 32, 36-40, 45, 52-55 and 62 are pending. Claims 1-26, 31, 32, 36-40, 45, 52-55 and 62 are rejected. The rejection of Claims 1-26, 31, 32, 36-40, 45, 52-55 and 62 is appealed.

IV. STATUS OF AMENDMENTS

All amendments have been entered.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Pursuant to 37 CFR § 41.37(c)(1)(v), a concise explanation of the subject matter defined in the independent claims involved in the appeal is provided below. References to the specification as filed, by page and line number, and to the drawings, if any, are provided in parenthesis below.

Claim 1

The invention defined in Claim 1 is a stepwise method of producing titanium-aluminium compounds and/or titanium-aluminium alloys (abstract; page 1, lines 6-16; page 4, lines 19-21 in combination with page 5, lines 7-11; Figure 8). The method comprises a first step of:

reducing an amount of titanium chloride (TiCl_4) with an amount of aluminium at a temperature to trigger reactions to form titanium subchloride(s) and aluminium chloride (AlCl_3) products (page 5, lines 7-11; page 14, lines 14-16; page 21, lines 21-25; page 23, lines 26-31; Figure 8); and then a second step of:

mixing said products, with the addition of more aluminium if required, and heating the mixture in a reaction zone to a temperature above 300C to form AlCl_3 in a gas phase, and to produce an end product in the reaction zone of the titanium-aluminium compounds and/or titanium-aluminium alloys (page 4, lines 21-24 and lines 30-34; page 14, lines 16-20; page 14, lines 20-25; Figure 8).

Claim 31

The invention defined in Claim 31 is a stepwise method of producing titanium-aluminium compounds and/or titanium-aluminium alloys (abstract; page 1, lines 6-16; page 4, lines 19-21 in combination with page 5, lines 7-11; Figure 8). The method comprises a first step of:

heating a mixture of TiCl_4 and aluminium to form products TiCl_3 and AlCl_3 , at a temperature less than 300C (page 5, lines 7-11; page 14, lines 14-16; page 21, lines 21-25; page 23, lines 26-31; Figure 8); and then a second step of:

mixing said products, with the addition of more aluminium if required, and heating the mixture to a reaction zone temperature above 300C to cause AlCl_3 to be evaporated from the reaction zone and to form titanium-aluminium compounds and/or titanium-aluminium alloys (page 4, lines 21-24 and lines 30-34; page 8, lines

31-36; page 14, lines 16-20; page 14, lines 20-25; Figure 8).

Claim 37

The invention defined in Claim 37 is a method for the production of vanadium and/or vanadium compounds (page 1, lines 6-7; page 11, lines 2-4 and lines 8-9; page 13, lines 5-9; page 25, lines 28-35). The method comprises the steps of mixing aluminium with a precursor material including vanadium subhalide, and heating the mixture, to form aluminium halides and vanadium and/or vanadium compounds (page 10, lines 16-25 and lines 34-37; page 11, lines 2-7).

Claim 39

The invention defined in Claim 39 is a method for the production of zirconium and/or zirconium compounds (page 1, lines 6-7; page 11, lines 11-12 and lines 17-19; page 13, lines 5-9; page 25, lines 28-35). The method comprises the steps of mixing aluminium with a precursor material including zirconium subhalide, and heating the mixture, to form aluminium halides and zirconium and/or zirconium compounds (page 11, lines 13-16).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The issues under appeal are:

- a) Whether Claims 1-7, 11-26, 31, 32, 36-40, 45, 52-55 and 62 are unpatentable under 35 U.S.C. §103(a) as being obvious over Nie et al. (US 2004/0050208).
- b) Whether Claims 8-10 are unpatentable under 35 U.S.C. §103(a) as being obvious over Nie et al. (US 2004/0050208) in view of O'Donnell et al. (US 5,397,375).

VII. ARGUMENT

A. The rejection of the claims under 35 U.S.C. §103(a) should be reversed because there are no references in the prior art that, taken individually or together, disclose each and every element or step of the presently claimed invention, nor are there any references that provide a teaching, suggestion, or motivation to modify the prior art in a manner to arrive at the presently claimed invention.

First, the Examiner has rejected Claims 1-7, 11-26, 31, 32, 36-40, 45, 52-55 and 62 as being unpatentable under 35 U.S.C. §103(a) over Nie et al. (US 2004/0050208). This rejection is improper because Nie et al. fails to disclose each and every feature or step of the presently claimed invention. This rejection is also improper because Nie et al. teaches away from the presently claimed invention. Moreover, this rejection is improper because Nie et al. does not provide any teaching, suggestion, or motivation to arrive at the presently claimed invention.

Second, the Examiner has rejected Claims 8-10 as being unpatentable under 35 U.S.C. §103(a) over Nie et al. (US 2004/0050208) in view of O'Donnell et al. (US 5,397,375). This rejection is improper because the cited prior art fails to disclose each and every feature or step of the rejected claims. This rejection is also improper because Nie et al. teaches away from the rejected claims. Moreover, this rejection is improper because Nie et al. does not provide any teaching, suggestion, or motivation to arrive at the invention recited in the rejected claims. Finally, the rejected claims all depend, either directly or indirectly, from independent Claim 1 and are thus allowable for at least the same reasons, as well as for the features that they recite.

State of the art

The ability of Al to reduce TiCl_4 has been known for more than 50 years and, since the development of the Kroll process (in which titanium metal is produced via the reduction of TiCl_4 with magnesium) and the Hunter process (in which titanium metal is produced via the reduction of TiCl_4 with sodium), many unsuccessful attempts have been made to replace Mg or Na with Al as a reducing agent in order to produce pure titanium or titanium-aluminium alloys.

In the prior art processes, attempts to reduce TiCl_4 with Al usually resulted in products that were non-uniform and contained a large amount of TiAl_3 (which are unsuitable for industrial use) because of the strong affinity between Al and Ti in such reactions. Thus, whilst it is well known that Al reacts with and reduces titanium-based halides, it has been an enduring problem in the art to overcome the strong affinity of Al and Ti and produce pure titanium and/or titanium-aluminium compounds having acceptable properties and at a competitive cost.

The problems associated with the use of Al as a reducing agent for TiCl_4 are also discussed in the patent literature, for example, in Jacobson (US 3252823), where it is stated that reaction rates between TiCl_4 and Al are inadequately slow at temperatures below 600°C , whilst at temperatures above 600°C the Al particles soften and stick together and yields become negligible. In an example describing the formation of a Ti-Al alloy (Example II), it is noted that the alloy particles produced varied in composition. This is consistent with the state of the art as discussed above, i.e. direct reduction of TiCl_4 with Al results in the uncontrollable formation of many different Ti-Al alloys, which is not commercially useful. The unsuitability of Al as a reducing agent for metal chlorides is also reported in numerous other US patents, including Nie et al., which is discussed below in detail.

A more recent attempt to reduce TiCl_4 with Al has been carried out at the Laboratories of the US department of Energy, and is explained in S.J. Gerdemann and D.D. Alman, "Titanium Aluminide powder production via reaction between TiCl_4 and Al", Gamma Titanium Aluminides 1999, ed Y-W Kim, D.M. Dimiduk; and M. H. Loretto, The Minerals, Metals and Materials Society, 1999, pp 341-346. This report concludes by stating "Clearly, it is possible to make TiAl by reduction of TiCl_4 with Al. However, the formation of a uniform product ... was not possible with the experimental apparatus utilised in these initial experiments."

The presently claimed invention

Aspects of the presently claimed invention relate to the unexpected discovery that if TiCl_4 is reduced with aluminium under controlled conditions and in a stepwise manner via titanium subchloride intermediates, then useful products can be obtained (see, e.g., the description between line 18 on page 7 and line 5 on page 8 of the PCT specification (as amended under Article 34)).

The inventor has unexpectedly found that if the reaction between TiCl_4 and Al is separated into two parts, whereby the heat generated in the first step is prevented from affecting the reactions carried out in the second step, then the reduction of TiCl_4 with Al can be controlled, which allows for control of the nature of the end products.

The invention defined by Independent Claims 1 and 31 is a stepwise method comprising a first step in which TiCl_4 is reduced using aluminium at a temperature to trigger reactions to form intermediates including titanium subchlorides and aluminium chloride. Subsequently, a second step is performed in which the products of the first step (with the addition of more aluminium if required) are heated to form the desired titanium-aluminium compound and/or titanium-aluminium alloy. Independent Claims 1 and 31 clearly recite (a) that the reduction of TiCl_4 proceeds via two steps, (b) that the TiCl_4 (and titanium subchlorides) is reduced with aluminium, and (c) that titanium subchloride intermediates are formed in the first step.

The invention defined by independent Claim 37 is similar to the method recited above except it involves the production of aluminium halides and vanadium and/or vanadium compounds and the method of Claim 39 is also similar except that it involves the production of aluminium halides and zirconium and/or zirconium compounds.

Nie et al.

Appellant respectfully asserts that Nie *et al.* relates to a completely different process for reducing TiCl_4 than that claimed in the present application. In particular, Appellant asserts that Nie *et al.* does not disclose a method that includes at least features (a), (b) and (c) of independent Claims 1 and 31, nor does it disclose each and every step of the methods disclosed in independent Claims 37 and 39.

Nie *et al.* teaches that a "precursor material" is reduced by a "reducing gas" to form an elemental material, or that "precursor materials" are reduced by a "reducing gas" to form an alloy material. Nie *et al.* specifically describes a process in which TiCl_4 is directly reduced to titanium metal using hydrogen gas. The reaction between TiCl_4 and hydrogen results in the formation of elemental titanium and hydrogen chloride gas. The hydrogen chloride gas is subsequently reacted with a "reductant material" (e.g. Al, Mn, Mg, Na, Ca, K, Li, Ba, Be, Ce, Cs, Hf, Pa, Rb, Sr, Th, U or Zr)

to form hydrogen for future use, and reductant chloride (e.g. AlCl_3 , if Al is the “reductant material”).

The reason that aluminium (or any of the numerous other “reductant materials”) is used in the method disclosed in Nie *et al.* is to cause the thermodynamically unfavourable reaction between TiCl_4 and H_2 to be driven by removing one of the products (i.e. HCl) of that reaction (see paragraph [0050]).

Feature (a)

In its broadest form (e.g. paragraph [0014]), Nie *et al.* discloses the reaction of a precursor material (e.g. TiCl_4) with a reducing gas (e.g. H_2) to form an elemental material (Ti) and a first reaction product (e.g. HCl). In paragraph [0019], Nie *et al.* generically discloses the reaction of more than one precursor materials with a reducing gas to form an alloy material.

Appellant respectfully asserts that Nie *et al.* solely discloses a one-step reduction process, in which the precursor material(s) is directly reduced to an elemental or alloy material. See, for example, the references to “Formula 1” throughout Nie *et al.* which clearly show the direct reduction of TiCl_4 with H_2 to Ti and HCl, and paragraph [0033], which clearly states that “The reducing gas reduces the precursor material to an elemental material.” The foregoing is also clearly stated in paragraph [0064], which describes that the reaction proceeds via the reactions represented by Formulae V and VI, in which TiCl_4 is directly reduced to Ti using H_2 .

Appellant respectfully asserts that Nie *et al.* provides no teaching, suggestion, or motivation that would prompt one of ordinary skill in the art to consider performing a stepwise reduction of TiCl_4 .

Feature (b)

Appellant asserts that Nie *et al.* does not disclose a method for producing titanium-aluminium compounds and/or alloys in which aluminium is used as the reductant. Indeed, Appellant asserts that Nie *et al.* clearly teaches (see, for example, paragraphs [0017], [0028], [0033], [0034], [0055], and [0060]-[0062]) that a reducing gas (e.g. H_2 , or one of the other gasses listed in paragraph [0034]) is essential to the process for producing elemental Ti or Ti-alloys.

In some embodiments described in Nie *et al.* (see e.g. paragraphs [0069] to [0072]), a “seed” may be included in the first reaction in order to form an “alloy of elemental materials.” Examples of a suitable “seed” include Al, B, Be, Ga, Sb, Ta, Mo, Nb, Sn, Cr, Fe, V, Mg, Na, Mn, Zr or Ca. However, Appellant asserts that in all of the methods disclosed in Nie *et al.*, the reduction of the precursor material is always caused by the reducing gas. In the embodiments involving a seed material, the reduced precursor material (e.g. Ti that has been reduced from TiCl_4 by H_2) deposits on the seed material (e.g. Al) to form an alloy with the seed material (see paragraph [0069]). The seed material does not reduce the precursor material.

Appellant further asserts that paragraphs [0060] to [0065] of Nie *et al.* clearly indicate that if Al was present when the TiCl_4 is reduced with H_2 , this would not react with the TiCl_4 . Nie *et al.* teaches that any reaction between TiCl_4 and Al would be limited by surface area and the heterogeneous nature of the reaction. In contrast, Nie *et al.* teaches that the reaction between TiCl_4 and H_2 is much more favourable because it is a homogeneous reaction, with the reactants having an effectively infinite surface area.

The Examiner has relied upon some isolated paragraphs in Nie *et al.* (e.g. paragraphs [0004] and [0063]), which indicate that Al can reduce TiCl_4 (which, as discussed above, is known in the art) to contend that Nie *et al.* teaches that Al could be used in place of H_2 to reduce TiCl_4 .

However, Appellant asserts that the context in which this disclosure is made clearly indicates that this is not envisaged or remotely suggested by Nie *et al.* For example, paragraph [0004] forms part of the Background of the Invention section of Nie *et al.*, which concludes with the statement (in paragraph [0011]) “The aforementioned methods all suffer from being unable to produce sufficiently pure materials in a sufficiently economical manner...” Therefore, Appellant respectfully asserts that Nie *et al.* effectively teaches away from using Al to reduce TiCl_4 .

Similarly, whilst paragraph [0063] indicates that “thermodynamic calculations” (which are based on computer simulations in which a number of assumptions have been made) indicate that TiCl_4 can be directly reduced with Al, the paragraphs preceding and following paragraph [0063] clearly indicate that Al is not a suitable reductant. Again, these sections of Nie *et al.* provide no teaching, suggestion, or motivation that would prompt one of ordinary skill in the art to use Al to directly

reduce TiCl_4 . Appellant has also included herewith the present Appeal Brief statutory declarations provided by Dr Jawad Haidar and Dr A.B. Murphy in response to an earlier Official Action issued in respect of the present application. Briefly, these statutory declarations discuss the fundamental differences between chemical equilibrium calculations and the reactions which will actually occur under typical conditions.

Appellant asserts that it is not appropriate for the Examiner to consider that certain isolated statements in Nie *et al.* constitute a teaching that would motivate one of ordinary skill in the art to seek to modify the process of Nie *et al.* to use Al instead of H_2 as a reductant. Appellant asserts that if Nie *et al.* is read as a whole, it clearly teaches that Al is an unsuitable reductant for TiCl_4 .

Indeed, when read as a whole, Appellant considers that Nie *et al.* clearly teaches away from using Al as a reductant. Throughout Nie *et al.*, TiCl_4 is only ever described as being reduced using a reducing gas. Paragraphs [0062] to [0066] describe the advantages of using a reducing gas such as H_2 compared to using a metal (e.g., Al or Mn) for reducing the precursor material. Paragraph [0063] mentions that thermodynamic calculations indicate that TiCl_4 can be reduced by Al or Mn, however, as noted above, paragraphs [0062] and [0066] clearly indicate that this is not a practical option. Indeed, Applicant asserts that paragraph [0066] acknowledges the state of the art (as discussed above) by stating "... as persons skilled in the art know, if TiCl_4 is reduced solely by a metal, the newly-born titanium metal and the produced metal halide, most of which is solid or liquid under preferred operating conditions, will form simultaneously on the surface of the reductant metal and be physically trapped by one another." Paragraph [0062] indicates that reductant metals (such as Al) have relatively small thermodynamic driving forces and states that "These small thermodynamic tendencies ... which leads to the very slow reaction rate or no reaction at all."

Appellant considers that this clearly acknowledges that reduction of TiCl_4 with Al would result in incomplete reactions and the formation of an uncontrollable mixture of products.

Feature (c)

Appellant further asserts that Nie *et al.* does not refer to the formation of intermediates during the reaction between TiCl_4 and H_2 , let alone the titanium subchloride and aluminium chloride intermediates explicitly recited in the pending claims. Even if the reaction of TiCl_4 with H_2 resulted in the formation of Ti subchloride intermediates, Nie *et al.* does not disclose the existence of these intermediates, let alone teach that these intermediates could be further reduced in a stepwise process with aluminium (and thus avoid the formation of undesirable product mixtures as discussed above). Further, as noted above in respect of feature (b), even should TiCl_4 come into contact with Al during the process of Nie *et al.*, Nie *et al.* teaches that the reaction between TiCl_4 and H_2 is much more favourable because it is a homogeneous reaction, with the reactants having an effectively infinite surface area. Thus, Appellant asserts that the method of Nie *et al.* could not possibly produce both of the intermediates recited in the pending claims.

Conclusion

Appellant respectfully asserts that the Examiner has not fully appreciated the state of the art, and has mischaracterised the teachings of Nie *et al.* Appellant asserts that one of ordinary skill in the art would not seek to reduce TiCl_4 with Al using the method of Nie *et al.* because it is well known in the art that this reaction would not result in the formation of useful products. Appellant does not consider that any disclosure in Nie *et al.* would motivate one of ordinary skill in the art to do so. Indeed, Appellant notes that the entire disclosure of Nie *et al.*, and especially paragraphs [0062] and [0066], clearly teaches that Al is an unsuitable reductant (which is consistent with the state of the art).

To support a *prima facie* case of obviousness, the Examiner must establish that the prior art discloses, either taken alone or in combination, each of the claimed elements or method steps. However, as is noted above, the cited prior art does not teach or suggest at least elements (a), (b) and (c) of independent Claims 1 and 31, nor does it teach or suggest each and every step of independent Claims 37 and 39.

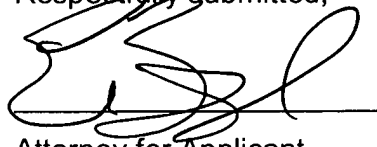
Since the prior art does not teach or suggest each and every element or step of the presently claimed invention, Appellant respectfully asserts that a *prima facie* case of obviousness cannot presently be established.

Furthermore, as described above, the primary reference relied upon by the Examiner (Nie *et al.*) clearly teaches away from certain aspects of the presently claimed invention.

In view of the foregoing, reversal of the rejections of Claims 1-7, 11-26, 31, 32, 36-40, 45, 52-55 and 62 under 35 U.S.C. §103(a) over Nie *et al.* and Claims 8-10 under 35 U.S.C. §103(a) over Nie *et al.* in view of O'Donnell *et al.* and allowance of these claims are respectfully requested.

July 30, 2010
Date

Respectfully submitted,



Attorney for Applicant
Eric D. Babych
c/o Ladas & Parry LLP
224 South Michigan Avenue
Chicago, Illinois 60604
(312) 427-1300
Reg. No. 57,542

VIII. CLAIMS APPENDIX

Listing of Claims

1. (Previously presented) A stepwise method of producing titanium-aluminium compounds and/or titanium-aluminium alloys, comprising a first step of:
reducing an amount of titanium chloride (TiCl_4) with an amount of aluminium at a temperature to trigger reactions to form titanium subchloride(s) and aluminium chloride (AlCl_3) products; and then a second step of:
mixing said products, with the addition of more aluminium if required, and heating the mixture in a reaction zone to a temperature above 300C to form AlCl_3 in a gas phase, and to produce an end product in the reaction zone of the titanium-aluminium compounds and/or titanium-aluminium alloys.
2. (Original) A method as claimed in claim 1, wherein the method also provides for driving the removal of AlCl_3 from the reaction zone to favour a forward reaction in the second step.
3. (Original) A method as claimed in claim 2, wherein the removal of AlCl_3 from the reaction zone is continuous.
4. (Previously presented) A method as claimed in claim 1, wherein the first step is conducted at a temperature above the boiling point of AlCl_3 .
5. (Previously presented) A method as claimed in claim 1, wherein the first step is conducted at a temperature above 200C.
6. (Previously presented) A method as claimed in claim 1, wherein the first step is conducted with an excess amount of aluminium present to reduce all of the titanium chloride (TiCl_4) to form said titanium subchloride(s) and aluminium chloride (AlCl_3) products.
7. (Previously presented) A method as claimed in claim 1, wherein the second step is conducted at a temperature in the range 300C to 1000C.

8. (Previously presented) A method as claimed in claim 1, comprising the further step of recycling at least some of the aluminium chloride formed, and utilising the aluminium chloride to produce TiCl_4 .

9. (Original) A method as claimed in claim 8, wherein the aluminium chloride is used to reduce titanium oxide to produce TiCl_4 .

10. (Original) A method as claimed in claim 9, wherein aluminium oxide is produced by reduction of titanium oxide, and the aluminium oxide is electrolysed to produce aluminium raw material for use in the method of any one of the preceding claims.

11. (Previously presented) A method as claimed in claim 1, wherein the aluminium chloride is condensed away from the reaction zone at a temperature lower than that in the reaction zone.

12. (Previously presented) A method as claimed in claim 1, wherein titanium subchloride which escapes the reaction zone is condensed at a temperature different to that in the reaction zone.

13. (Original) A method as claimed in claim 12, comprising the further step of returning the condensed titanium subchloride to the reaction zone.

14. (Previously presented) A method as claimed in claim 1, also comprising the step of introducing a source of one or more elements selected from the group comprising chromium, niobium, vanadium, zirconium, silicon, boron, molybdenum, tantalum and carbon, and products of said method include titanium-aluminium compounds and/or titanium aluminium alloys which include one or more of these elements.

15. (Original) A method as claimed in claim 14, wherein the source of the element(s) can be a metal halide, a subhalide, a pure element or another compound

which includes the element.

16. (Previously presented) A method as claimed in claim 14, wherein the products also include one or more of an intermetallic compound, a titanium-(selected element)-alloy, and intermediate compounds.

17. (Previously presented) A method as claimed in claim 14, wherein the source includes vanadium subchloride, and a product of said method is an alloy or intermetallic complex including titanium, aluminium and vanadium.

18. (Original) A method as claimed in claim 17, comprising the steps of adding the source in appropriate proportions, and carrying out the method to produce Ti-6Al-4V.

19. (Original) A method as claimed in claim 14, wherein the source includes zirconium subchloride, and a product of the method is an alloy or intermetallic complex including titanium, aluminium, zirconium and vanadium.

20. (Previously presented) A method as claimed in claim 14, wherein the source includes niobium halide and chromium halide, and a product of said method is an alloy or intermetallic complex including titanium, aluminium, niobium and chromium.

21. (Original) A method as claimed in claim 20, comprising the step of adding the source in appropriate proportions, and carrying out the method to produce Ti-48Al-2Nb-2Cr.

22. (Previously presented) A method as claimed in claim 1, wherein the aluminium is added in the form of a powder having an approximate upper grain size of less than about 50 micrometres.

23. (Previously presented) A method as claimed in claim 1, wherein the aluminium is in the form of a powder of an approximate upper grain size of greater than about 50 micrometres, and the method comprises the step of milling the aluminium powder and titanium subchloride to reduce the grain size of the aluminium

powder in at least one dimension.

24. (Previously presented) A method as claimed in claim 1, wherein the aluminium is in the form of flakes having a thickness in one dimension of less than about 50 micrometres.

25. (Previously presented) A method as claimed in claim 1, wherein the method is conducted in an inert gas atmosphere or in a vacuum.

26. (Previously presented) A method for production of a powder of titanium-aluminium intermetallic compounds including at least one of Ti_3Al , $TiAl$ and $TiAl_3$, and alloys based on titanium-aluminium intermetallics as claimed in claim 1, wherein starting materials for the method include aluminium powder and titanium chloride.

27. – 30. (Cancelled)

31. (Previously presented) A stepwise method of producing titanium-aluminium compounds and/or titanium-aluminium alloys, comprising a first step of:
heating a mixture of $TiCl_4$ and aluminium to form products $TiCl_3$ and $AlCl_3$, at a temperature less than 300C; and then a second step of:
mixing said products, with the addition of more aluminium if required, and heating the mixture to a reaction zone temperature above 300C to cause $AlCl_3$ to be evaporated from the reaction zone and to form titanium-aluminium compounds and/or titanium-aluminium alloys.

32. (Previously presented) A method as claimed in claim 31, wherein the method also provides for driving the removal of $AlCl_3$ from the reaction zone to favour a forward reaction in the second step.

33. – 35. (Cancelled)

36. (Previously presented) A method as claimed in claim 1, comprising the further step of adding a reagent to a product of the method to produce a further product.

37. (Original) A method for the production of vanadium and/or vanadium compounds, comprising the steps of mixing aluminium with a precursor material including vanadium subhalide, and heating the mixture, to form aluminium halides and vanadium and/or vanadium compounds.

38. (Original) A method in accordance with claim 37, wherein the vanadium compounds may include vanadium-aluminium alloys and/or vanadium aluminium intermetallic complexes.

39. (Original) A method for the production of zirconium and/or zirconium compounds, comprising the steps of mixing aluminium with a precursor material including zirconium subhalide, and heating the mixture, to form aluminium halides and zirconium and/or zirconium compounds.

40. (Previously presented) A method in accordance with claim 39, wherein the zirconium compounds may include zirconium-aluminium alloys and/or zirconium-aluminium intermetallic complexes.

41. – 44. (Cancelled)

45. (Previously presented) A titanium compound, a metal compound or a product produced by the method as claimed in claim 1.

46. – 51. (Cancelled)

52. (Previously presented) A method as claimed in claim 31, wherein the first step is conducted at a temperature above the boiling point of AlCl_3 .

53. (Previously presented) A method as claimed in claim 31, wherein the first step is conducted at a temperature above 200C.

54. (Previously presented) A method as claimed in claim 31, wherein the first step

is conducted with an excess amount of aluminium present to reduce all of the titanium chloride (TiCl_4) to form said TiCl_3 and aluminium chloride (AlCl_3) products.

55. (Previously presented) A method as claimed in claim 31, wherein the second step is conducted at a temperature in the range of 300C to 1000C.

56. – 61. (Cancelled)

62. (Previously presented) A titanium compound, a metal compound or a product produced by the method as claimed in claim 31.

63. (Cancelled)

IX. EVIDENCE APPENDIX

- (1) US Patent No. 3,252,823 Jacobson et al.

This reference was cited in an Information Disclosure Statement filed April 28, 2008.

- (2) S.J. Gerdemann and D.D. Alman, "Titanium Aluminide powder production via reaction between $TiCl_4$ and Al", Gamma Titanium Aluminides 1999, ed Y-W Kim, D.M. Dimiduk; and M. H. Loretto, The Minerals, Metals and Materials Society, 1999, pp 341-346.

This reference was cited in an Information Disclosure Statement filed May 9, 2006.

- (3) US Patent Application Publication No. 2004/0050208 Nie et al.

This reference was first cited by the Examiner in an Office Action dated June 25, 2009.

- (4) US Patent No. 5,397,375 O'Donnell et al.

This reference was first cited by the Examiner in an Office Action dated July 9, 2008.

- (5) Affidavit under 37 CFR 1.132 by Jawad Haidar submitted on May 1, 2009.

- (6) Affidavit under 37 CFR 1.132 by Anthony B. Murphy submitted on May 1, 2009.

X. RELATED PROCEEDINGS APPENDIX

None.